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A. B. CONNER, DIRECTOR
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DIVISION OF CHEMISTRY

Relation of the Water-Soluble Potash, the Replaceable, and Acid-Soluble Potash to the Potash Removed by Crops in Pot Experiments

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SYNOPSIS

One part of the very complex problem of soil fertility is its relation to the chemical composition of the soil, and this Bulletin deals with a phase of this aspect of the problem. The fertility of the soil in potash as measured by its capacity to supply potash to crops in pot experiments is related to the water-soluble potash, the replaceable potash, and the active potash of the soil. The amount of potash taken up by crops of corn and kafir or milo usually averages about one-half the replaceable potash and five to six times the water-soluble potash in the soil. The losses of potash from the soil by cropping are reflected in the loss of the soil in water-soluble potash and in replaceable potash. The amount of potash removed by the crops from the soil averages about 3 to 16 times the water-soluble potash lost in cropping and about twice the replaceable potash lost in cropping. The active potash is still considered the best measure of the ability of the soil to supply potash to crops. The differences between the amounts of potash removed by a first and a second extraction of the soil with nitric acid become greater as the potash taken up by crops increases. Correlation coefficients for the factors studied show close relations between them. Correction of the 0.2N nitric acid for neutralization by the bases of the soil in the estimation of active potash is not advisable.

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RELATION OF THE WATER-SOLUBLE POTASH, THE REPLACEABLE, AND ACID-SOLUBLE POTASH TO THE POTASH REMOVED BY CROPS IN POT EXPERIMENTS

G. S. FRAPS

The relation of the chemical composition of the soil to soil fertility is a fundamental and difficult problem of agricultural chemistry. Soil fertility is the resultant of many factors; its relations are influenced not only by the quantity of the various compounds present, and they by one another, but by other conditions, such as the physical character and conditions of the soil, and other variables such as moisture, temperature, and bacterial action. Field results as measured by yields are influenced by the factors just mentioned and others in addition, such as the depth of the surface soil, the depth of subsoil, and variations in the physical character of the soil. Many soils are so variable that the difficulty of sampling may so result that the samples taken do not represent the field sampled, as has actually occurred.

The potential fertility of the soil, as such, must be distinguished from the productiveness of the soil as measured by crop yields. The soil may, for example, have a high capacity to supply potash to plants, varying, no doubt, to some extent according to the nature of the plant. The crop grown, however, may not be able to take up the potash, owing to the adverse operation of other factors, or, having taken it up, may not be able to effect a corresponding production of grain or other crop, due likewise to other factors. What applies to potash applies also to phosphoric acid, nitrogen, and other factors of fertility; the power of the soil to supply one or more of them is not necessarily reflected in the yield of the crop. The ability of the soil to supply, and the power of the crop to use, are two separate things, and must be considered separately. This is an elementary principle of agricultural chemistry, which seems, however, sometimes to be forgotten.

The fertility of a soil in any factor is here defined as the power of the soil to furnish that factor, regardless of the ability of a crop to utilize it. The author at present knows no better measure of the fertility of a soil in potash than the amount of potash which crops can remove from that soil under standard conditions. As crops vary in their power to take soil potash, it is necessary also to select some definite crop or to call attention to the fact that the results apply to the crops selected under the conditions under which they were grown.

Some chemists have found little relation between the chemical composition of the soil and its fertility, but others have had better success.

It is evident that the factors of fertility must be studied separately, both independently and in relation to one another, before they can be recombined to represent any particular soil complex.

Comparison of the chemical analysis of the soil with the results of pot experiments at the Texas Agricultural Experiment Station extending over a number of years has shown that chemical methods for potash (Bulletins 145, 190, 384, 325, and 355), phosphoric acid (Bulletins 126, 178, 212, 267), and nitrogen (Bulletins 151, 259, 283) give results that are closely related to particular plant food furnished by the soil in pot experiments. Chemical analysis cannot be used as an exact measure of the fertility of soil in some particular plant food, but can be used to divide the soils into groups within which other factors come into play and may have greater influence than the plant food studied. That is to say, with soils which differ to a decided extent in plant food, we would also expect corresponding differences in their reaction to the plant food studied, not exact but approximate. Soils of the same group as regards a particular plant food may also differ in their reaction to plant food on account of the play of other factors, but these differences within the groups should be smaller than without the groups. The fact must be emphasized that the quantity of potash in the soil is only one of the factors which influence the relation of the soil potash to the crop, and while it is important as regards soil fertility, the fact that the chemical content is only one factor must not be forgotten.

Some of the methods tested are better adapted to the purpose than others. The work is being continued for the purpose of testing additional methods of analysis and for studying other factors which enter into the problem.

Previous bulletins have shown that the active potash of the soil is the best measure yet found of the ability of the soil to furnish potash to crops in pot experiments. The object of the present bulletin is to discuss the relation of some of the other forms of potash in the soil to the potash furnished to crops. The water-soluble potash, the potash soluble in 12 per cent hydrochloric acid, the replaceable potash, and the potash extracted by successive extractions with 0.2 N nitric acid are discussed, as well as the question of neutralizing the basicity of the soil in the estimation of the active potash. This Bulletin is the sixth in a series dealing with the potash of the soil, the preceding ones being Bulletins 145, 190, 284, 325, and 355.

METHOD OF WORK

The pot experiments were carried out as described in Bulletin 325 and others. The quantity of soil used was 5000 grams, the pots were kept in a greenhouse, and the first crop grown was usually corn, the second kafir, or sorghum. The potash in the dried crop was estimated in the usual way. The results are presented in parts per million of soil except when otherwise specified.

WATER-SOLUBLE POTASH

Investigators of the potash soluble in water in the soil have used a variety of methods. The results have been used both for purposes of investigation and for judging the ability of the soil to yield potash to plants. The potash soluble in water at any given time may be in proportion to the total amount soluble, but is less than the amount which dissolves during the season of cropping. When potash is removed from the solution by the plant, an additional amount probably enters into solution, though the strength of the soil solution is not necessarily kept constant. The rate at which the solution occurs would depend on the nature of the material, the quantity of potash compounds present, and other factors, and it would have an effect on the amount of water-soluble potash furnished to the plant. The water extract of a soil, however made, does not necessarily represent the soil solution. The soil is a mixture of particles of various kinds; the aqueous solution surrounding a particle containing soluble potash may be quite different from that surrounding a particle which absorbs potash. The water extract to a certain extent must contain an amount of potash between the high and low content surrounding the various particles.

Method of Analysis

Since the estimation of the amount of water-soluble potash can be only relative and not absolute, the method used for its estimation was arbitrary. It is described as follows:

Place 200 gm. of the soil in a bottle with 2000 c.c. water in a water bath heated to 40° C., and keep at 40° five hours. Shake every half hour. Filter on a double fluted filter. Evaporate 1600 c.c. to about 100 c.c., filter and wash. Evaporate the filtrate nearly to dryness in an evaporating dish, add 3 c.c. nitric acid and 8 c.c. hydrochloric acid, evaporate to complete dryness, and heat for about 30 minutes at about 120° C. Take up with acid and water, and filter into an evaporating dish. Evaporate the solution to dryness with 5 c.c. conc. hydrochloric acid; take up with water and 2 or 3 c.c. hydrochloric acid; filter and wash, if necessary. Add 2 c.c. platinum chloride and evaporate to dryness.

Let cool, add about 10 c.c. acid alcohol, and break up material by stirring. Wash three or four times with about 10 c.c. acid alcohol by decantation. If the potash salts appear to be pure, transfer to a Gooch with a new felt and wash about 8 times with 95 per cent alcohol. If the precipitate is not clean, wash with ammonium chloride, using small amounts, then with alcohol. Dry in a steam oven, and calculate to parts per million water-soluble potash.

Relation of Water-Soluble Potash to Potash Removed by Crops

Table 1 contains the average results arranged by potash soluble in water. With the exception of the first group, the average amount of potash removed by the first crop and by two crops increases regularly as the average amount of water-soluble potash extracted from the soil increases, up to 48 parts per million of water-soluble potash in the soil. Beyond this point, the results are somewhat erratic, though the potash taken up by the crop shows a tendency to increase as the water-soluble potash in the soil increases. The amount of potash taken up by the first crop averages three or four times as much as the water-soluble potash in the soil. The amounts of potash taken up by the two crops usually average 5 to 6 times as much as the water-soluble potash in the soil.

Table 1.—Potash in Parts Per Million of Soil Arranged in Groups by Water-soluble Potash.

Number of Soils	Group	Potash Taken Up by First Crop	Potash Taken Up by Two Crops	Water-soluble Potash in Soil Before Cropping	Water-soluble Potash in Soil After Cropping	Active Potash in Soil
14	6–12	81	125	10	10	103
27	12.1–18	66	98	15	10	100
40	18.1–24	93	140	21	14	129
29	24.1–30	111	160	27	13	154
16	30.1–36	132	188	33	13	162
28	36.1–42	140	192	39	12	212
12	42.1–48	176	251	45	14	238
17	48.1–54	131	194	51	17	222
12	54.1–60	216	311	57	15	284
12	60.1–66	209	283	63	23	281
6	66.1–72	188	302	69	19	375
1	72.1–78	201	399	74	11	402
2	78.1–84	182	315	80	34	541
5	84.1–90	284	393	86	35	621
1	108.1–114	491	665	114	37	628
2	120.1–126	342	522	124	35	832
2	126.1–132	309	505	132	21	540
2	162.1–168	393	569	164	42	1409

The correlation coefficient, r, for the potash in 2 crops and water-soluble potash is $+ .703 \pm .022$.

Relation of the Water-Soluble Potash to the Active Potash

Table 1 also shows the average active potash contained in the soils on which water-soluble potash was determined. The active potash tends to increase as the water-soluble potash increases, though the averages are somewhat irregular. There is thus a relation between the active potash and the water-soluble potash, as was to be expected.

The correlation coefficient, r, for the water-soluble potash and the active potash is $+ .789 \pm .017$. The correlation between the water-soluble potash and the active potash is closer than between the water-soluble potash in the soil and the potash removed by crops.

Effect of Cropping on the Water-Soluble Potash

The estimation of water-soluble potash in a soil before and after cropping in the pot experiments frequently (though not always) shows a decrease in water-soluble potash caused by cropping.

Table 1 gives the average water-soluble potash before and after cropping, which can be compared with the potash removed by two crops. There is a loss of water-soluble potash due to cropping but it is only a small part of that removed by the crop, especially in the first group.

Table 2 compares the potash removed by the crops with the loss in water-soluble potash and the loss in active potash from the soil before and after cropping. The soils are averaged in groups according to the potash removed in the crops, and the averages only are given. This is a different arrangement from Table 1, which is arranged according to the water-soluble potash in the soil. The loss in water-soluble potash is, as could be expected, much lower than the potash removed by cropping or than the loss in active potash. With the first groups the loss in water-soluble potash averages about one-third the amount taken up by the crop, but with the other groups the loss in water-soluble potash is from 6 to 12 per cent of that removed by the crop.

Table 2.—Potash in Crops Compared with Loss of Active Potash and Water-soluble Potash from the Soil in Parts Per Million.

Number of Soils	Group	Potash in Crops	Loss of Active Potash from Soil	Water-soluble Potash in Soil Before Cropping	Water-soluble Potash in Soil After Cropping	Loss Water-soluble from Soil
11	0–50	42	16	28	13	15
34	51–100	80	32	21	12	9
72	101–200	151	61	30	14	16
47	201–300	240	95	37	15	22
22	301–400	352	169	47	15	32
10	401–500	457	201	54	20	34
12	501–600	546	275	74	19	55
12	601–700	633	241	55	17	38
2	801–900	884	607	101	36	65
1	901–1000	934	549	124	35	89

POTASH SOLUBLE IN 12 PER CENT HYDROCHLORIC ACID

In some European countries the potash in the soil is estimated by extraction with 12 per cent hydrochloric acid at room temperature.

The following method of analysis was used in the work here reported:

To 900 c.c. hydrochloric acid C. P. add 1800 c.c. water, make 20 c.c. up to 200 c.c. and titrate 10 c.c. with 0.1 N ammonia. Make up so that 10 c.c. ($\mp$ 1 c.c. of acid) = 33.3 c.c. 0.1 N ammonia. This acid is 3.33 N. Digest 10 grams soil for 24 hours with 100 c.c. of the above hydrochloric acid at room temperature, shaking occasionally. Filter and wash with hot water. Add 1 c.c. nitric acid. Evaporate to dryness and heat on steam bath to render silica insoluble. Take up with hydrochloric acid and hot water, filter and wash. Evaporate to about 20 c.c. Add 5 c.c. platinum chloride solution, and evaporate to a paste, or to dryness if possible. Let cool. Add 10 to 30 c.c. acid alcohol with stirring (10 c.c. concentrated hydrochloric acid to 100 c.c. alcohol 95 per cent). Pour off the alcohol through a weighed Gooch crucible and wash again with the acid alcohol. Then wash with 95 per cent alcohol by decantation until no colored material is dissolved. When the colored material has been washed out—not less than 8 washings—pour on 10 c.c. ammonium chloride solution and allow it to stand a few minutes to dissolve the impurities. Pour off the wash liquid through the Gooch crucible, and repeat the washing three times or more if necessary to remove all white material or other foreign material from the platinum precipitate. Then wash the potash salt into the Gooch crucible with 95 per cent alcohol and wash eight times with alcohol. Dry for an hour or more in the steam oven, cool in desiccator, and weigh.

Relation of Potash Soluble in 12 Per Cent Hydrochloric Acid to Potash Removed by Crops

Table 3 contains the average results of the analyses arranged according to the potash soluble in 12 per cent hydrochloric acid. The potash in the crops increases with the potash soluble in 12 per cent hydrochloric acid up to about .075 per cent, aftér which it is irregular. The active potash in the soil increases in a similar way. The potash soluble in 12 per cent acid is about twice the active potash up to .044 per cent acid-soluble potash or 185 parts per million of active potash, after which it is usually three times as much, though sometimes much more.

Table 3.—Potash in Parts Per Million of Soil Arranged by Percentages of Potash Soluble in 12% Acid.

Number Averaged	Group Per Cent	Potash in First Crop Per Million	Potash in Second Crop Per Million	Potash Soluble in 12% Acid in Soil Per Cent	Active Potash in Soil Per Million
5...........	0-.01	32	54	.007	57
30...........	.0101-.02	59	79	.016	83
47...........	.0201-.03	101	137	.029	149
36...........	.0301-.04	125	168	.035	165
20...........	.0401-.05	133	190	.044	185
15...........	.0501-.06	145	216	.055	220
11...........	.0601-.07	180	261	.064	287
11...........	.0701-.08	202	312	.075	303
10...........	.0801-.09	192	289	.085	253
8...........	.0901-.10	209	334	.097	306
9...........	.1001-.11	270	374	.109	329
5...........	.1101-.12	249	383	.115	272
3...........	.1201-.13	307	368	.124	444
8...........	.1301-.14	235	361	.134	342
2...........	.1401-.15	277	442	.142	402
3...........	.1601-.17	256	348	.165	515
1...........	.1801-.19	144	304	.186	561
2...........	.1901-.20	342	522	.199	832
1...........	.2201-.23	126	162	.227	256

The correlation coefficient, r, for the potash in two crops (227 tests) and the potash soluble in 12 per cent acid is $+ .720 \pm .022$.

REPLACEABLE POTASH IN THE SOIL

It has been known for many years that portions of such bases in the soil as calcium, magnesium, or potassium could be replaced by other bases. This phenomenon of fixation was extensively studied by Way and others about 1860 (Fraps' Principles of Agricultural Chemistry, p. 234). In recent years the subject has been given renewed attention, and studies under the name of base exchange have given some very significant results, especially in relation to alkali soils and the cause of the difficulty of reclaiming them by leaching (Kelly and Brown, Soil Science *20*, 473). Soils in which the replaceable calcium and magnesium have been replaced to a large part by sodium, run together easily, which causes the penetration of water to be very slow. Replacing the sodium by calcium makes the soil more permeable and more easily penetrated by water.

The replaceable potash in the soil can be estimated by means of treatment with a strong solution of ammonium chloride and repeated washing with the same solution. The method used is based on that described by Hissink (Soil Science *15*, 269).

Dissolve 365 gm. ammonium chloride in ten liters of distilled water. Weigh 24.23 grams of soil into a beaker, add 100 c.c. ammonium chloride solution and stir well. Let stand over night. Filter into a 500 c.c. graduated flask and wash to volume with ammonium chloride solution, allowing all the liquid to pass through before adding fresh portions. Evaporate to about 75 c.c., put in a deep beaker, and slowly add a mixture of 20 c.c. conc. nitric acid and 4 c.c. hydrochloric acid. Evaporate to dryness and take up with 10 c.c. hydrochloric acid and 2 c.c. nitric acid. Again evaporate to dryness. Take up in a little hydrochloric acid and water, filter and wash, add platinum chloride solution, and complete as for potash in soils.

Relation of the Replaceable Potash to the Potash Removed by Crops

Table 4 contains the results of the work arranged according to the replaceable potash. The potash removed by the crops increases with the first groups, then becomes somewhat irregular, with a tendency to increase as the potash soluble in ammonium chloride increases. The replaceable potash is greater than the active potash. The active potash increases with the potash soluble in ammonium chloride, though not as rapidly; so there are greater differences between the two when the soils are high in replaceable potash than when they are low.

The correlation coefficient, r, for the replaceable potash in the soil and the potash removed by two crops is $+.910 \pm .012$.

The correlation coefficient, r, between the replaceable and the active potash is $+.879 \pm .016$.

In similar work on active potash, the correlation coefficient for active potash in the soil and the potash removed from 271 soils in pot experiments, r, is $+.794 \pm .014$. However, when the correlation was calculated for the active potash and the potash removed by crops for the same 88 soils used for replaceable potash, the correlation coefficient was $+.886 \pm .015$. There is thus little difference between the correlation coefficients for the replaceable potash and for the active potash. From a laboratory standpoint, the estimation of active potash is to be preferred.

Table 4.—Relation of Replaceable Potash to Potash Removed by Crops and to Active Potash in Parts Per Million of Soil.

Number Averaged	Group According to Replaceable Potash	Potash in First Crop	Potash in Two Crops	Replaceable Potash in Soil	Active Potash in Soil
1	50.1–75	26	40	68	35
2	75.1–100	36	53	77	60
17	100.1–125	44	63	118	70
19	125.1–150	66	95	140	85
15	150.1–175	75	106	171	111
3	175.1–200	74	109	182	85
6	200.1–225	100	133	213	154
4	225.1–250	112	137	245	142
1	275.1–300	73	142	296	65
4	300.1–325	114	150	311	100
3	325.1–350	97	184	336	125
2	375.1–400	81	125	385	122
1	425.1–450	142	209	432	142
2	475.1–500	325	459	495	257
2	500.1–525	192	308	521	401
1	600.1–625	320	430	612	312
5	650.1–675	310	445	682	533

Relation of Potash Removed by Crops to the Loss of Replaceable Potash by the Soil

The estimation of replaceable potash and active potash was made on some of the soils after they had been cropped in the pot experiments. The loss in replaceable potash caused by the cropping is the amount before cropping less the amount after cropping. The potash removed from the soils by the crops was compared with the loss in replaceable potash and with the loss in active potash. The results are given in Table 5, arranged according to the potash removed by the crops.

Table 5.—Relation of Potash Lost from the Soil to the Loss of Active and of Replaceable Potash in Parts Per Million in the Soil.

No.	Group According to Potash Removed by Crop	Potash in Crops	Loss of Active Potash by Cropping	Replaceable Potash Before Cropping	Replaceable Potash After Cropping	Replaceable Potash Lost by Cropping
11	0–50	42	16	120	100	20
20	51–100	79	24	132	102	30
31	101–200	145	42	201	140	61
1	201–300	238	35	184	130	54
1	401–500	460	68	521	244	277
3	501–600	527	309	661	350	311
4	601–700	639	171	564	343	221
1	701–800	735	140	771	380	391

The loss in replaceable potash and the loss in active potash are both related to the potash removed from the soil by the crops. The loss in replaceable potash averages a little more than the loss in active potash, and is a little closer to the amount actually found. It is evident that the crop does not feed entirely on the replaceable potash, or that the replaceable potash as measured by the method here used does not take out all the potash on which the plant can feed.

A statistical study of the 72 results give the correlation coefficient between the potash removed by the crops and the loss in replaceable potash, r, to be $+ .797 \pm .029$. A previous study of the potash removed by cropping and the loss in active potash on 408 samples gave r as $+ .722 \pm .016$. When the same group of 72 soils was used for the calculation, the correlation coefficient for the active potash was found to be $+ .780 \pm .031$ or practically the same as for the replaceable potash.

Discussion of Results for Replaceable Potash

The close relation between the replaceable potash in the soil and the potash removed by crops, and the fact that the replaceable potash in the soil is not merely lowered by cropping, but the extent of the decrease is related to the amount of potash removed by the crops, afford excellent evidence that the replaceable potash is used by the crops to a greater extent than the other potash, and that the replaceabl potash is a measure of the strength of the soil as regards potash. The same considerations apply to active potash, but the amount of potash removed by cropping is reflected to a somewhat greater extent by the replaceable potash than by the active potash. The active potash and the replaceable potash no doubt for the most part came from the same forms of combination in the soil, though the replaceable potash is somewhat larger in quantity.

The laboratory manipulation of the estimation of active potash is somewhat simpler and less difficult than that for replaceable potash, and for this reason it is better adapted to routine work relative to the fertility of different soils.

RELATION OF THE LOSS IN EXTRACTION OF ACTIVE POTASH TO THE LOSS IN CROPPING

As previously pointed out, when a soil is cropped, there is a loss of active potash, but the loss is less than the amount of potash removed. Likewise when the extraction of active potash by 0.2 N nitric acid is followed by a second extraction, an additional quantity of potash is secured, equal to about one-fourth to one-half of the active potash secured by the first extraction. Additional extractions will give up further quantities of potash, although the amount will decrease, usually gradually but sometimes quite abruptly.

The ability of a soil to maintain its supply of active potash, both to cropping and to acid solvents, must be of significance both to soil fertility and to soil chemistry. It may be asked whether the active potash remaining after one cropping or more is as readily taken up as that originally present; whether additional amounts of potash become available during the crop year; to what extent differences in active potash, if any, due to cropping, already exist in soils under investigation. Similar questions arise as to the relations of the active potash removed by successive extractions; what is the relative values of the potash to plants as represented by the successive extracts; what is the relation of the amount in the successive extracts to the fertility of the soil as regards potash; what is the relation of the potash lost by extraction to the loss by cropping. These are some of the questions which arise.

The first extraction with 0.2 N nitric acid does not remove all the potash soluble in this solvent. Successive extractions will give additional quantities of potash, the amounts depending upon the nature of the soil. The potash in the second extract may average one-half that of the first extract in soils low in active potash. The proportion decreases as the active potash in the soil becomes larger until the second extract may average one-fourth or less of the first extract in soils high in active potash.

The difference between the first and second extraction with 0.2 N nitric acid is here termed the loss in extraction, as a matter of convenience. The loss in extraction is, of course, less than the active potash secured by the first extraction.

Relation of the Loss in Extraction to the Potash in Crops

Table 6 contains the data averaged according to the loss of potash in extraction as defined above. The loss of active potash in extraction of the soil with acid is closely related to the active potash lost from the soil by cropping. The relations are indeed remarkably close, considering the fact that one is a chemical process and the other a process of assimilation by the plant, in which the amount removed depends upon the plant and other conditions. The loss in extraction is also related to the active potash, the active potash increasing almost regularly with the loss of potash in extraction.

The potash in the second extract of the soil is related to the active potash remaining in the soil after cropping, as is shown in Table 7. The active potash left after cropping in the soils low in active potash is larger than the potash in the second extract, which indicates a possibility that some other potash is converted into active forms during the cropping. This would indicate that some of the insoluble potash has been rendered soluble during the growth of the crop. When a soil is cropped, there is a loss of active potash. When a soil is extracted with 0.2 N nitric acid, there is a loss of soluble potash. In neither case is the soluble potash completely exhausted.

Table 6.—Relation of Loss in Extraction of Active Potash to Loss of Active Potash by Cropping in Parts Per Million.

Number Averaged	Group by Loss in Extraction	Loss Active Potash in Extraction	Loss Active Potash in Cropping	Active Potash
4	1–25	0	11	106
13	25.1–50	36	36	78
15	50.1–75	63	34	85
18	75.1–100	91	72	135
16	100.1–125	111	78	161
23	125.1–150	140	112	185
12	150.1–175	164	165	277
6	175.1–200	186	166	273
1	200.1–225	212	85	273
7	225.1–250	229	270	371
3	250.1–275	263	251	376
3	275.1–300	296	208	456
2	300.1–325	303	194	400
1	325.1–350	333	168	441
1	375.1–400	379	232	434
1	500.1–525	521	432	628
2	575.1–600	594	575	832
1	725.1–750	742	708	1045
1	1025.1–1050	1048	593	1409
1	1050.1–1075	1051	683	1409

Table 7.—Relation of the Potash in the Second Extract from the Soil to the Active Potash in the Soil After Cropping, in Parts Per Million.

Number Averaged	Averaged by Groups	Potash in Second Extract	Active Potash After Cropping
27	1–25	19	46
43	25.1–50	37	67
19	50.1–75	61	89
7	75.1–100	89	150
3	100.1–125	117	205
6	125.1–150	134	164
2	150.1–175	155	60
8	175.1–200	194	111
6	225.1–250	237	162
2	275.1–300	287	100
2	300.1–325	313	387
2	400.1–425	407	771

EFFECT OF THE NEUTRALIZATION OF THE BASICITY ON THE ACTIVE POTASH AND RELATION TO CROPPING

One procedure for the estimation of active potash is to extract the soil directly with 0.2 N nitric acid; another is first to estimate the amount of 0.2 N nitric acid neutralized by the lime and magnesia in other bases of the soil, and then to use sufficient acid to make the solution 0.2 N after the extraction. Each method has its advocates.

For the purpose of this study, the soils were divided into two groups. One group includes those soils which neutralize less than 85 per cent of the acid; the other group, those which neutralize 85 per cent or more of the acid. The active potash had already been determined in these soils, without correction of the acid for neutralization. For the purpose of the work, a preliminary digestion was made with acid; sufficient acid was used to insure 0.2 N nitric acid after digestion; and a test was made of the strength of the acid after the digestion to see that such was the case. The remainder of the work was similar to that already described.

Results of the Work

The results secured were studied in the following way: The potash which should be removed from the soil by one crop was calculated from Table 3 in Bulletin 355, both for the active potash and for the potash removed when the acid was corrected for the bases removed. From these figures were subtracted the amounts of potash actually removed by the average of the two crops grown. The difference shows the extent to which the actual results differ from the calculated results. The average results are summarized in Table 8.

Table 8.—Potash Removed by One Crop Compared with That Calculated for Active With and Without Correction for Acid Consumed.

	Number of Soils			Total Amount of Difference			Net Difference Per Soil	Average Difference
Acid Consumed less than 85%	+	—	Total	+	—	Total		
Active potash not corrected..	30	24	54	739	754	—14	—0.3	29
Active potash corrected for acid consumed	44	10	54	1885	305	+1580	29	40
Acid Consumed more than 85%								
Active potash not corrected.	3	14	17	86	911	—825	—49	57
Active potash corrected for acid consumed	13	3	17	717	74	+643	+38	40

For soils neutralizing 85 per cent or less of the acid, the amounts of potash to be removed by the crops calculated from the active potash (without correction for acid neutralized) average very close to the actual results secured; the net difference per soil is —0.3, while the average difference, plus and minus, is 29 parts per million. When the soil was corrected for acid consumed, the results of the interpretation averaged 29 parts per million higher than the actual; the average difference, plus and minus, was 40. Thus, the calculated results are more closely in accordance with the actual results when the correction for acid consumed is not made. The analysis is also a little shorter when the correction for acid consumed is not made.

The results are somewhat different when soils are used which consume 85 per cent or more of the acid. With 17 of these soils, both the average difference and the net difference between the calculated amounts of potash removed and the actual amounts removed, are slightly in favor of making the corrections. The calculated value runs lower than the actual potash removed, when based upon the active potash not corrected for neutralization, than when the potash corrected for acid consumed is used. With both methods, however, the average difference and the net difference are greater than for soils low in bases.

It does not seem that the degree of accuracy is improved by making the correction for acid consumed. It would probably be better not to make correction for acid consumed during the analysis, but to consider the characteristics of soils high in lime in making the interpretation of the results. The interpretation of analysis of such soils is more difficult than that of less basic soils, as they are usually high in active potash, and most of the potash taken up by plants is affected by other factors than the quantity presented by the soil.

SUMMARY OF CORRELATION COEFFICIENTS

The correlation coefficients were calculated from the original data and not from the averages given in the tables. The following is a summary of the correlation coefficients secured:

Water-soluble potash and potash in 2 crops: $+ .70 \pm .02$.

Water-soluble potash and active potash: $+ .79 \pm .02$.

Potash soluble in 12 per cent hydrochloric acid and potash in two crops: $+ .72 \pm .02$.

Potash soluble in 12 per cent hydrochloric acid and active potash: $+ .72 \pm .02$.

Replaceable potash and potash in two crops: $+ .91 \pm .01$.

Replaceable potash and active potash: $+ .88 \pm .02$.

Active potash and potash in 2 crops, the same soils used for replaceable potash: $+ .89 \pm .02$.

Replaceable potash lost from the soil in cropping and potash in the crop grown: $+ .80 \pm .03$.

Active potash lost from the soil in cropping, the same soils used for replaceable potash, and potash in the crops grown: $+ .78 \pm .03$.

SUMMARY AND CONCLUSIONS

The water-soluble potash in the soil, the potash soluble in 12 per cent hydrochloric acid, and the replaceable potash in the soil are all related to the potash removed by crops in pot experiments and to the active potash of the soils.

The water-soluble potash lost from the soil by cropping and the replaceable potash lost by cropping are related to the amount of potash taken up by the crop grown on the soils and to the active potash lost by cropping.

The amount of potash taken up by two crops usually averages 5 to 6 times the water-soluble potash in the soil and about one-half the replaceable potash in the soil.

The amount of potash removed by the crops from the soil is usually 8 to 16 times the water-soluble potash lost in cropping and about twice the replaceable potash lost *in cropping*. The loss of replaceable potash in cropping is greater than the loss of active potash by cropping.

The difference in the amounts of potash removed by a first and second extraction of soils with 0.2 nitric acid becomes greater as the potash taken up by the crops in the pot experiments increase.

When a soil neutralizes 85 per cent or less of the acid used, the interpretations of the results are more closely in accordance with the results of the pot experiments when the *correction is not* made for the neutralization of the acid, than when it is made.

When the soils neutralize more than 85 per cent of the acid, the interpretation of the results varies from the actual results a little less when correction is made for acid consumed than when it is not, but in both cases the deviation is more than for less basic soils. It appears better not to correct for neutralization but to take the highly calcareous nature of the soil into consideration in making the interpretation of the results.